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Projects in VR: The Naval Postgraduate School's Moves Curriculum

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Projects in VR

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The Naval Postgraduate School's Moves Curriculum

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Naval Postgraduate School

Both the National Research Council (NRC) report "Virtual Reality: Scientific and Technological Challenges"[1] and the more recent NRC report "Modeling and Simulation: Linking Entertainment and Defense"[2] discuss the need for nontraditional degree programs—programs that focus more closely on the issues of how we develop the software and content for networked virtual environments (VEs). Both reports point out that the more effective VE developer is not just a computer scientist, electrical engineer, or human factors specialist, but rather a scientist who sits in-between, a scientist whose education melds the precise parts required for developing VEs. To produce such graduates requires new degree programs. The Naval Postgraduate School (NPS) has developed one such program, the Modeling, Virtual Environments, and Simulation (Moves) degree program (http://www.moves.nps.navy.mil/). We present the composition of that degree program and its relationship to the research our students can then handle at the end of that program.

Tradition, tradition

Creating new degree programs or variants of existing ones is probably the fastest way to alienate your colleagues, especially if you're connected to an existing degree program with hundreds of man-years of tradition. But creating new degree programs is necessary, since traditional programs collect lots of fat material perhaps not central to the program's goals or included for purely historical reasons. This is a problem with all fields (computer science, electrical engineering, human factors, operations research, physiology, cognitive psychology and others) out of which we conduct VE research. Unfortunately, not much give exists in traditional curricula. Requesting more leeway or creating a new program will probably be the best way to invite yourself to a hanging. Leaving students in older degree programs means graduating them with only part of the education they need. At NPS, we opted for the more directed, focused approach.

Making sausage

Once you decide to create a new degree program—especially something as interdisciplinary as VEs—the process becomes somewhat akin to making sausage. We looked at what we had been doing successfully and kept that. That list told us what to omit from the current degree program. We then had to decide what to add back into the program.

The NPS VE research and education efforts were initiated by the NPSNet Research Group (http://npsnet.nps.navy.mil/).[3] For the past decade, this group has focused on human-computer interaction and software technology for implementing large-scale virtual environments (LSVEs). That research has been applied to constructing VEs for the US Department of Defense.

Before we created the Moves curriculum, NPSNet students completed a traditional computer science MS degree, specializing in computer graphics and visual simulation. We kept the following courses from the computer science MS program:

- Introduction to Object-Oriented Programming in C++
- Computer Systems Principles
- Data Structures
- Introduction to Computer Architecture
- Artificial Intelligence
- Introduction to Physically Based Modeling
- Operating Systems
- Computer Communications and Networks
- Distributed Operating Systems
- Computer Graphics
- Interactive Computation Systems
- Symbolic Computing
- Virtual World and Simulation Systems

This part of the Moves degree program aims to provide students with a basic computer science background and focus on courses that provide programming skills. We wanted our students to be capable computer programmers at the core level and generally comfortable with the technology on which their futures will rest. We used existing computer science department courses in the same quarters as currently offered to minimize the new degree program's costs.

With programming strength as the main ingredient in our degree program, we then attempted to define the rest of the program's focus. We had strong pressure to add operations analysis modeling courses from NPS' Operations Research Department to increase the ability of our students to model human behaviors and systems and to provide them with skills for evaluating human performance in a VE. We all agreed that mathematical sophistication was a strong component of all future VE systems, so added the following operations analysis courses:

- Probability
- Probability and Statistics
- Statistics
- Data Analysis
- Stochastic Models I
- System Simulation
- Human Performance Measurement

Like the computer science courses we selected, the operations analysis courses were from an existing curriculum and offered in the normal quarter. Again, we hedged our bets by doing this to make the curriculum mostly cost-free, riding on the backs of existing course offerings from traditional degree programs.

A fork in the curriculum

Traditionally, the NPSNet project has focused on developing technology for visual simulation of VEs. The NPSNet project is quite large and has been successful with that focus. In the scope of new work now going on at NPS (both within and outside of the NPSNet Research Group), we also had to provide education that supports the study of human-computer interaction technology use and evaluation as applied to VEs. We could not agree on a single educational plan to meet both objectives. Again, the issue was not wanting to load the curriculum with material unrelated to the student's selected objective. To solve this problem, we created two tracks: a visual simulation track in Moves that focuses on technology development for the VE and a human-computer interaction track that focuses on technology use and human performance evaluation for VEs. In designing these two tracks, we did not preclude adding new tracks. Currently, we're discussing creating a physically based modeling track.

For the Moves visual simulation track, we added the following courses to the degree program:

- Introduction to Multimedia Production
- Image Synthesis
- Computer Animation
- Physically Based Modeling
- Virtual Environment Network and Software Architectures
- Human Performance Evaluation

For the Moves human-computer interaction track, we added the following courses:

- Mobile Computing Systems
- Human Performance Measurement II
- Simulation Methodology
- Human Performance Evaluation
- Designing Virtual Environments I, II, and III
- Training in Virtual Environments
- Human Performance Analysis in the VE I, II, and III

The human-computer interaction (HCI) track has more required courses because NPS has more associated faculty and a mature set of courses. For the HCI track we have started planning the implementation of Moves-specific courses, including Designing Virtual Environments, Training in Virtual Environments, and Human Performance Analysis in the VE. We're currently offering or planning prototype versions of these courses.

Who are the students?

We've defined a rather robust eight-quarter, two-year MS degree program in modeling, VEs, and simulation. Additionally, we have submitted a PhD program based on the MS degree to the NPS Academic Council. Students coming into the Moves curriculum have BA or BS degrees from the Naval Academy or other universities in a spectrum of subjects, ranging from divinity to philosophy. For the Moves curriculum (and all NPS curricula), we assume no prior technical preparation other than a BA or BS degree and that the US military has deemed the officer promotable, hence worthy of two years at the Naval Postgraduate School. The Navy created a subspecialty that requires the Moves degree and will send 10 officers per year to the Moves program. The US Army also created a subspecialty for modeling and simulation and will send five officers per year to the program.

Thesis research in the Moves program

We strongly believe that a graduate curriculum is only as good as the research it produces. All Moves students must successfully complete a thesis to graduate. The first group of Moves MS-degree program students are in the process of selecting their thesis topics and beginning their research. Topics for MS theses are often, but not always, selected from projects funded reimbursably to participating Moves faculty. Such topics include the design of LSVE network software architectures, Web-based interoperability, cross-platform VE toolkits, 3D VE construction, inertial motion tracking, locomotion devices, human modeling in the VE, uses of spatial sound, wayfinding in the VE, architectures for computer-generated VE characters, and DoD applications of VE technology. The following summarizes some of the thesis projects under way.

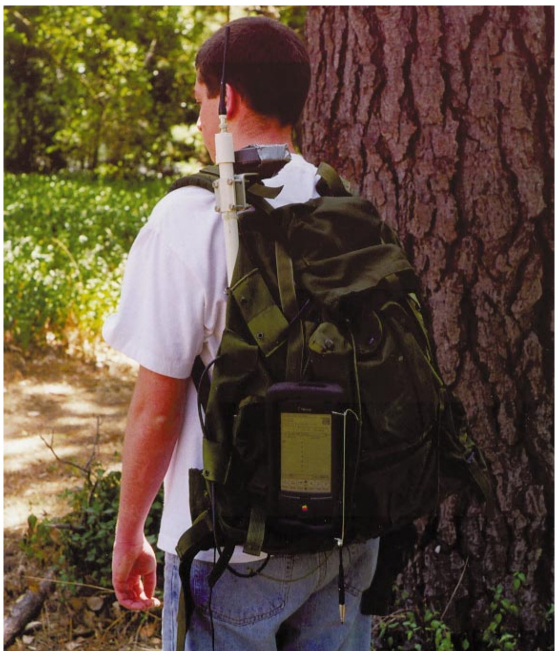
Bamboo: A cross-platform VE toolkit

One of our most important efforts has been developing Bamboo, an extensible framework for building networked VEs that collects the core mechanisms common to networked VEs.[4] An API toolkit for experienced programmers, Bamboo has a dynamically extendible runtime environment. We developed Bamboo because we needed a low-cost, general-purpose, cross-platform, high-level toolkit that provides a well-designed framework facilitating VE application research and development.

Improving the consistency of large-scale simulations

Consistency in networked VEs is a major area of concern as models become more complex, networks cover a wider geographic area, and developers increase the number of entities in each model. However, most work in this

1 **Helmet-mounted data collection apparatus.**



2 **Differential global positioning system (GPS) backpack.**

3 **Admiral's walk in Herrmann Hall.**

area has concentrated on the consistency of each entity in a VE. We're focusing instead on the models that simulate those entities. We believe that this work will show consistency can be achieved without using client-server models that track each entity. The thesis research aims to ensure that each simulation host has the same algorithms to model each type of entity. We're using Bamboo to dynamically load and unload program modules during runtime. Network communication is accomplished using the Defense Modeling and Simulation Office's High-Level Architecture (http://www.dmso.mil). A referee module running at each site ensures that the same modules run at each site.

Navigation training using VEs

Four students are currently working on theses related to navigation in large-scale VEs. The first of these completed a study comparing performance on a sport orienteering task between individuals who were trained using only maps, a VE with the maps, or the real environment with the maps.[5] Figure 1 shows this student equipped with a helmet-mounted video camera for data collection. Figure 2 shows a typical participant in the study with position-tracking equipment.

Later, a group of students did a course project to replicate this study in a complex building. Using Herrmann Hall, our administration building, they studied how people learn intricate routes on multiple floors of this historic structure. Figure 3 shows a view of the mezzanine level of the VE.

Finally, two experienced helicopter pilots investigated this same problem in terms of low-altitude air navigation. These students are currently working with a helicopter squadron at the Naval Air Station North Island in San Diego, California to construct and evaluate a training system to help student pilots learn to visualize terrain from contour maps. Figure 4 shows the apparatus for this system.

VE model construction

An interesting spin-off of the navigation and LSVE research has been an investigation of techniques for constructing high-fidelity geometric models of real environments for our simulations and trainers. As seen in Figure 3, a significant amount of detail might be required in a VE to achieve the desired effect, whether a specific level of performance, transfer of training, or simply immersion into the simulated space. Our other thesis projects address measuring these effects that drive the requirements of how detailed a model must be. We're investigating methods for constructing both man-made (building interiors) and natural environments.

Active locomotion in VEs

A fundamental part of navigation is locomotion, or the mechanism used to get from here to there. Many such mechanisms have been proposed and built, including the recent Omni-Directional Treadmill (ODT).[6] A student conducted a study of this device while it was at NPS for integration with NPSNet-IV. Figure 5 shows the ODT in operation. The results of this study uncovered a method for evaluating devices and techniques based on their adherence to human abilities.

Cognitive modeling of ship handling operations

Another student is working on developing a cognitive model of ship handling tasks for a larger project for the Surface Warfare Officer School (SWOS) in Newport, Rhode Island. A previous student had constructed a real-time simulation of an LPD-17 and amphibious vehicle (see Figures 6 and 7). Our current student (an experienced surface warfare officer) is using this and other surface-ship simulators to model the task so we can develop training systems using simulations that address the primary training needs at the necessary fidelity level.

Lessons learned

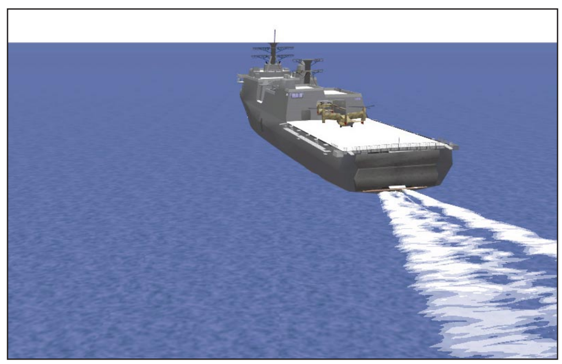
We did not create a department but rather a degree program of existing courses from several departments. This decreases the need for funding to support the degree program in its early stages. We strove to include all interested parties in the degree definition process, but also tried to move quickly before the degree got buried in "favorite course loading." (We did end up with some of that.) We pushed the degree program through the Academic Council at NPS as soon as we thought we were ready and received approval for the program. Defining the program with enough flexibility to include future unanticipated technologies was the best lesson we learned. ■

Acknowledgments

We wish to thank N6M, the Navy Modeling and Simulation Management Office, and the US Army for their sponsorship of the Moves curriculum.

4 **Wide field-of-view helicopter navigation trainer.**

5 **NPSNet-IV and the Omni-Directional Treadmill.**



6 **LPD-17 and wake.**

7 **Inside the LPD-17 with the amphibious vehicle.**

References

1. Committee on Virtual Reality Research and Development, Nat'l Research Council, *Virtual Reality: Scientific and Technological Challenges*, N. Durlach and A. Mavor, eds., National Academy of Sciences Press, Washington, DC, 1995.
2. *Modeling and Simulation: Linking Entertainment and Defense*, M. Zyda and J. Sheehan, eds., National Academy Press, Washington, DC, Sept. 1997, p. 181.
3. M. Zyda et al., "NPSNet—Large-Scale Virtual Environment Technology Testbed," *Proc. Int'l Conf. on Artificial Reality and Tele-Existence*, Virtual Reality Society of Japan, Tokyo, Dec. 1997, pp. 18-26.
4. K. Watsen and M. Zyda, "Bamboo—A Portable System for Dynamically Extensible, Networked, Real-Time, Virtual Environments," *Proc. VRAIS 98*, IEEE Computer Society Press, Los Alamitos, Calif., 1998, pp. 252-259.
5. R. Darken and W. Banker, "Navigating in Natural Environments: A Virtual Environment Training Transfer Study," *Proc. VRAIS 98*, IEEE Computer Society Press, Los Alamitos, Calif., 1998, pp. 12-19.
6. R.P. Darken, W.R. Cockayne, and D. Carmein, "The Omni-Directional Treadmill: A Locomotion Device for Virtual Worlds," *Proc. ACM Symp. on User Interface Software and Tech. (UIST 97)*, ACM Press, New York, 1997, pp. 213-221.

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